Measurement of microvibrations in the STAR experiment

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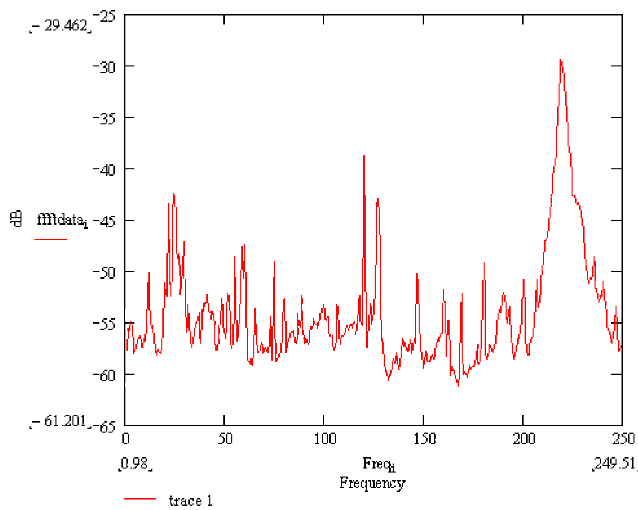

FIG. 1: Average power spectrum from 256 FFT's.

Understanding a tracking detector's environment is crucial to making high precision measurements. The pixel detector upgrade, which has a planned position resolution of ~ 10 microns, is such a detector. To achieve this goal, all possible contributions to the errors must be considered. Vibrations on the pixel detector that are out of phase with the rest of the STAR detector will affect the ultimate position resolution obtainable. An example of this would be a resonant excitation in the ladder of the pixel detector

The vibration measurements were made using an Endevco type 86 seismic accelerometer mounted onto the STAR detector, The accelerometer output was AC-coupled to a web-controlled Agilent scope running Windows 98 which provided the necessary online data acquisition and Fast Fourier Transform (FFT) analysis. The accelerometer has a sensitivity of 10 V/g and a range of ± 0.5 g's. Both the power spectrum and phase information were recorded and stored to a local hard-drive in the scope. Data was extracted over the network and the analysis was done at LBNL.

Figure 1 shows the average of 256 FFT's acquired with the scope. It is possible to derive the response of our detector elements to this power spectrum by using the tools available in the Solidworks CAD/finite element analysis package. One can convert the FFT power spectrum that represents RMS voltage to a RMS displacement amplitude by

$$A_f = \frac{C}{(2\pi f)^2} \times 10^{\frac{V_f}{20}}, \tag{1}$$

where A is the amplitude, f is the frequency, V is the power specific frequency and C is a trivial factor accounting for the dynamic range of the accelerometer and the input impedance to the FFT. The physical displacement is then reconstructed by summing the contributions from each discrete f in the Fourier transfrom by:

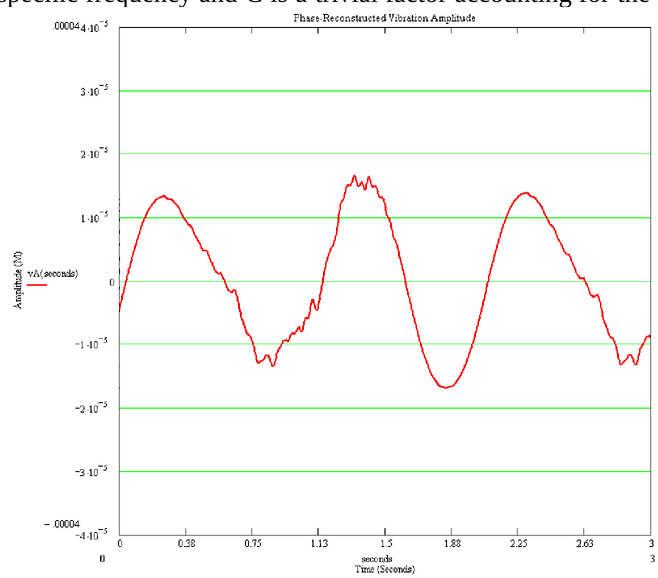

FIG. 2: Detector displacement measured at STAR.

$$D(t) = \sum_i A_{f_i} \sin(2\pi f_i t - \phi_i). \tag{2}$$

Figure 2 shows the displacement results from one acqusition with the scope. This is representative of the magnitude of the displacements, which typically are about 10 microns and dominated by the low frequency components. This is acceptable since the resonant frequency of our carbon fibre ladders is $\simeq 135$ Hz.